Classroom Attendance Monitoring System Using Radio Frequency Identification with Web Application

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Abstract

Throughout the years, attendance monitoring has widely evolved from manual methods to the integration of technology. Manual attendance monitoring in an institution consumes time, hard to maintain, prone to human error, and leads to misplaced or lost records. Individuals also tend to take advantage of the flaws of the manual method that leads them to commit hoax and forgery. Despite the innovation of different automated systems, biometric recognition systems, RFID technology, and barcodes also have disadvantages. To address the shortcomings of the existing methods and to minimize the contingencies, this paper describes the use of a web application that utilizes an ultra-high frequency (UHF) RFID with a motion sensor to monitor the attendance of students from the University of San Carlos. A Raspberry Pi 3 Model B is used in controlling the input and output, in which it is outputted on an LED. Wireless communication is used between the hardware system and the web system to record and validate students' attendance records. A web application is developed for faculty, students, and chairperson to monitor class attendance and to minimize contingencies. In addition, the faculty can edit and generate a seating plan.

Keywords: attendance monitoring, radio frequency identification, web application

1   Introduction

The Department of Education in the United States (U.S.) reported that in the year 2013 to 2014, a percentage of 14 students were chronically absent nationwide, which means a percentage of 10 or more of the school days were missing [11]. According to the study of Demir and Karabeyoglu [10], absenteeism is defined as a behavior of students refusing to attend school, lack of interest staying in class, arriving late, or skipping classes. The causes of absenteeism are classified into three areas: individual, family, and school; where students may feel academically pressured, find classes boring, have health problems, financial problems, poor learning environment, and etc. A study was conducted at the University of San Carlos on the reasons for college student's absences, and most of the reasons were about health and personal matters [7]. Absenteeism is considered to be the beginning of poor academic performance that leads to dropping out of school, however, it does not only affect their performance in an educational institution but also their success and social life [11].

One of the solutions in reducing absenteeism is the improvement in monitoring of attendance. Attendance monitoring on a daily basis improves students' performance by submitting requirements on time, increasing self-confidence, understanding the lessons, and enhancing communication skills to peers and teachers. The method is also a way for counselors and administrators to better understand the problems

of absenteeism in relation to students and their academic performance, and also one way to identify students with continuous or pattern of absences [13].

Attendance record of any organization in the business establishment is necessary to keep track of the entry and exit time of every worker which would also allow the educational institutions to monitor the records in each class provided that there are many classes in a day [12]. Monitoring and management of attendance is a challenging task in which the collection of the attendance information should be accurate to continue with the organization's activities without encountering problems [4].

In an industrial environment, some companies are still using logbooks and punch-cards in keeping track of the worker's attendance. The drawback of the logbook method is the manipulation and inaccuracy of attendance records as the worker's time in and out can be changed. Moreover, a lot of time is wasted in signing in and out using a logbook [15]. On the other hand, the punch-card system used by companies is laborious for the human resource (HR) practitioner to manage and organize the attendance records of each worker, and also for supervisors as they cannot regularly monitor the updates and performance of the workers regarding their attendance [16].

In an educational institution, usual methods of checking attendance are through signatories on a piece of paper, roll call, and looking at seating arrangement; and several related issues were identified such as students committing forgery and hoax [7]. The aforementioned issues will lead to unjust actions such as passing a falsified report and the institution wrongly rewarding students who did not do well in their studies [6]. The manual way of taking attendance also consumes time and hard to maintain in the long run [17], and leads to cases of lost, misplaced attendance record, or skipped student's name during a roll call [7].

The problems that were encountered by the industrial and educational sectors regarding the manual system of monitoring attendance led to the innovation of different automated systems such as biometric recognition systems, RFID technology, and barcodes. The said systems also have drawbacks in which implementing biometric systems are complex, costly, and inaccurate if there are physical deformation and distortion of the body; RFID technology is prone to impersonation or spoofing; the barcode can easily be duplicated. The systems do not completely eliminate integrity and contingency problems [8]. For that reason, it is necessary to have an efficient and effortless attendance monitoring system that addresses the shortcomings of the existing systems and that minimizes the contingencies in a class.

A comparative study has been conducted by the researchers in which different technologies were used in implementing an automatic attendance monitoring system. Based on the findings of the aforementioned study, implementing RFID is the most suitable technology for school settings considering its efficiency, cost, and availability in the market . To further understand the RFID technology, different RFID frequencies were compared based on their unique features, capabilities, and applications. The researchers concluded that UHF RFID technology is the most appropriate technology in tracking and monitoring objects.

1.1   Goals and Objectives

The purpose of this study is to develop a classroom attendance monitoring system using a web-based application that utilizes UHF RFID with a motion sensor system for academic institutions. Specifically, the system aims to achieve the following objectives:

- Create a hardware module for classroom attendance with the following features:

  - Walk-in RFID reader using UHF
  - Motion sensor
  - Hardware controller

        ∗ To transmit and receive data to and from the backend system.

        ∗ To receive data from the RFID reader and motion sensor.

        ∗ To display data validation from the server using a light-emitting diode (LED).

- Create a web-based application for attendance monitoring

  – Allow users to log in and log out.

  – Allow faculty users to view and edit attendance records, and generate and edit a seat plan.

  – Allow the student users to view their attendance records.

  – Allow chairperson user to view a detailed output of a class attendance record.

- Create an attendance monitoring system that displays the following information:

  – List of classes with class code, schedule, and room number.

  – Summarize daily attendance report.

  – Class list with the attendance record.

  – Seat plan

1.2 Scope and Limitation

This study focuses on the attendance system for the students of the University of San Carlos in which the faculty can view and edit the monitoring system, students can only view their attendance record, and the department chairperson can only view the detailed attendance record in a class.

Most of the hardware modules of the system detect objects, therefore the students must not be within a minimum range of 0.5 meters (m) from the detection area to avoid unwanted and unnecessary readings. The motion sensors cannot identify a specific person but only detect if someone enters and exits the classroom, and also cannot detect multiple human movements thus entering and exiting should be organized and in a single line.

The overall system relies on a small network in which the users can only access the web application through the local network provided by the server.

The study is only limited to the Bunzel Building, specifically rooms managed by the Department of Computer Engineering (CpE) and the Department of Mechanical and Manufacturing Engineering (MME), and not applicable for outdoor classes.

1.3 Significance of the Problem

The study would be beneficial to the following:

- Faculty members. They will be able to monitor class attendance effortlessly and eliminate the burden of keeping and tracking records with the use of paper or computerized lists. They will be able to utilize lecture hours as it eliminates the time spent in manual attendance checking, and further assess their methods in teaching.

- Students. They will be able to maximize their learning time inside the class since the time in attendance checking is reduced. In addition, they will be able to monitor their attendance in their enrolled classes to correct or report any inaccurate information recorded in their attendance.

- Chairperson. The web application will enable them to track and monitor their students.

- The university. The system will help them achieve the standards of quality education of different service 2 institutional organizations that accredits academic programs.

2   Background

RFID technology communicates with an RFID tag attached to an object using radio waves. In an RFID system, user input will be determined by scanning an RFID card or tag using an RFID reader, and data will pass on a middleware going to the database for validation. One of the operating frequency bands of RFID called UHF can operate between 860 to 960 MegaHertz (MHz) which has two types of tags, passive and active. Passive tags are low cost, with an estimated price of 0.10 US dollars (Php 5.09) per tag, amongst other tags because it does not require a battery cell and it has an average range of 2 to 5 m. In contrast, active tags are expensive, estimated to be around 20 US dollars (Php 1,018.36), because it uses an internal power source. According to the National Telecommunications Commission in the Philippines [19], the allowable frequency bands for UHF is 918 to 920 MHz. To achieve the allowable frequency band, the antenna sets the reading range and width of the reader in relation to gain and polarization. The gain which is measured in decibels (dB) is the product of directivity, an antenna's ability to focus on a certain direction, and radiation efficiency. Thus, the higher the gain the narrow the area covered or the beamwidth of the reader. In polarization, there are two types: linear sends radio frequency waves in a tag with a fixed position, while circular sends waves in either clockwise or counterclockwise motion and is best when the tag position differs [18].

Passive infrared (PIR) motion sensor detects movement from a human up to 7 m and is made of a pyroelectric sensor that detects levels of infrared radiation. The sensor is divided into 2 halves in order to detect any motion or change in infrared (IR) levels. The sensor triggers when a warm object passes by the first half of the sensor which causes a positive differential change between the two halves, and the sensor generates a negative differential change when the warm object leaves the proximity. Both slots detect the same IR level from the environment when the sensor is idle. The sensor uses a lens that condenses light creating a range of multiple, scattered, and small sensing areas that are in a conical form. These condensed lights are in a three-dimensional dome pattern. PIR motion sensor is commonly used in homes and businesses as they are low power and inexpensive [5].

A single-board computer (SBC) contains a microprocessor, memory, input or output (I/O), and other modules built on a single circuit board. Another SBC comes with I/O interfaces that support networking and wireless communication. As a compact and efficient computer, it is mostly applied in monitoring, controlling, and many others. SBC can do automation tasks and has varying specializations depending on its design [9].

The web application enables users to access and distribute documents anytime and anywhere with the help of a server, which serves and process scripts; and a database, which stores databases of the application [20]. Scripting languages could be used to design the user experience (UX) that focuses on improving the functionality and optimization of a product for effective and pleasurable use. The user interface (UI) design will be responsible for guiding the user visually through the application's interface [14].

3   Methodology

3.1   Attendance Monitoring System

The attendance monitoring system, as shown in figure 1, is composed of two domain: the in-classroom hardware domain (ICHS) and the web domain. The former starts operation with students carrying a UHF RFID passive tag, which follows the ISO 18000-6C standards, to the RFID reader. In turn, the UHF RFID reader, which is operating at 918 - 920 Megahertz frequency and an antenna with a gain of 26 decibel, checks presence of tag every 10 milliseconds interval. It obtains the unique ID of the tag if its within the 3 meter vertical reading range. A time-in event occurs exactly at the start of each class.

Before RFID tag detection, two integrated PIR motion sensors must first identify the entry and exit of the students. An unregistered tag and person that enters and exits without a tag is detected by the reader and PIR motion sensor, respectively. The respective information are sent to the Raspberry-Pi (RPi) 3 Model B, which is programmed with C++ and equipped with WiFi module to connect with the network. Subsequently, the RPi sends these data to the backend system for record and verification. The backend system responds the verification result to RPi, which in turn displays valid and invalid user using green and red light emitting diode (LED), respectively.
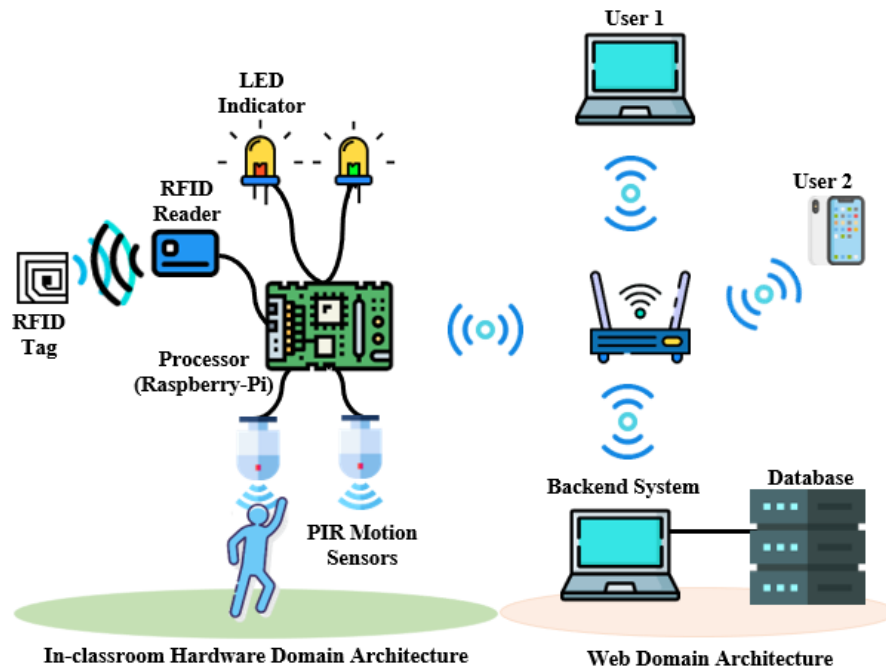

Figure 1: The Architecture of Attendance Monitoring System

The different components of the in-classroom hardware system, that includes RPi, RFID reader, antenna PIR motion sensor, a placed in a chassis while the LED indicators are mounted on a custom made stand as illustrated in Figure 2. When an RFID tag is detected, no other tag holder should be within the 0.5 meter minimum distance from the detection area to avoid unnecessary and unwanted readings. In case of rooms with more one access doors, only one door installed with the system must be be utilized.

On the other hand, the web domain also utilizes wireless communication to send and receive user information to and from the different components of the developed attendance monitoring system. The router serves as a local area network access point as well as sending and routing of packets. All of the users are able to access the web application of the system through localhost address.

Cross-Platfrom (X), Apache (A), MariaDB (M), PHP (P), and XAMPP served as local server for the system where it was connected to a wireless router and the database. On the backend system, PHP programming language was used for managing the data to and from the web application and hardware system. Moreover, it was also used in accessing data to and from the database via the web server. The system's database used MySQL to store the data of the hardware system and information of the users. These data and information included motion sensor's data, student's logging time, name, ID number, ID picture, tag's ID, course name, code and description, year, class schedule, department name, attendance record, username, and password. The detailed flow of the overall system is illustrated in Figure 3

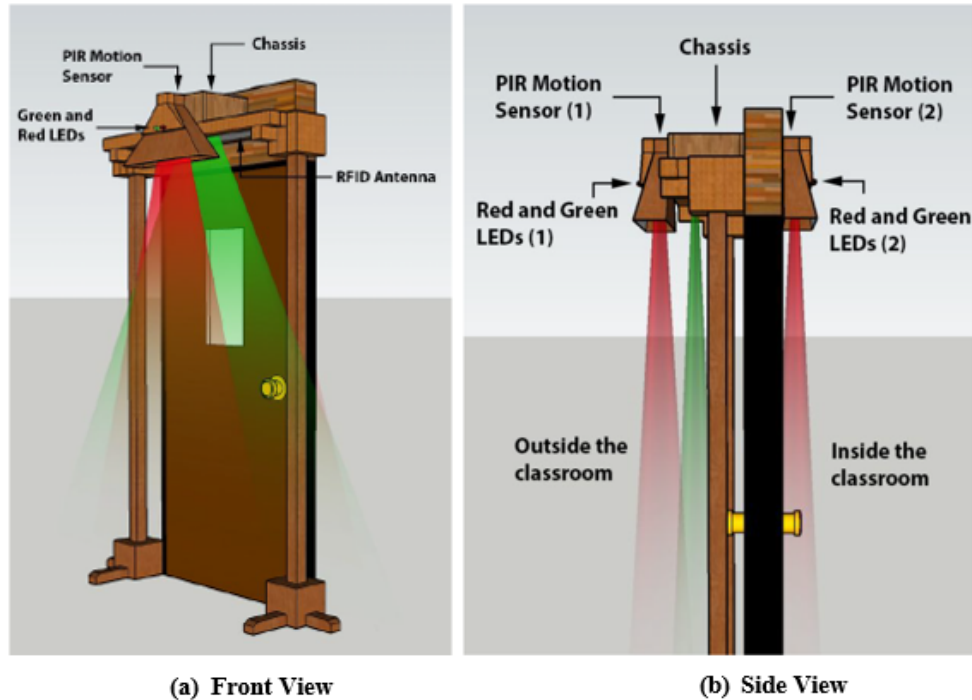(a) Front View   (b) Side View

Figure 2: Views of the Mounted In-classroom Hardware System

3.2 Web Application

A modern responsive front-end framework based on Google's Material Design, called Materialize, was used in the development of UI design that contained the features of Hypertext Markup Languange (HTML), Cascading Style Sheets (CSS), and JavaScript [21]. HTML provided the basic structure for the visualization of the web page. CSS scripting language helped in formatting and styling web pages. In addition, JavaScript helped in developing visualization and special effects.

3.2.1 Login Page

Faculty, students, and the chairperson were required to login before accessing their respective dashboards with the use of their ID number as the default username and password. A forgot-password button was provided on the login page, and the reset process of the password was through a newly inputted password.

3.2.2 Faculty Dashboard

The dashboard, shown in Figure 4, displayed the list of classes handled by the faculty. The attendance page and summarized attendance reports of each class per day were viewed through the 'View' button.

A menu bar was displayed on the sidebar that redirects the faculty to the dashboard, seat plan page, settings page, and logout. In addition, the name, ID number, and department name of the faculty were displayed.

Seat Plan Page   The seat plan page allowed the faculty to view, edit, or generate automatically or manually a seat plan of a selected class. When viewing the class's seat plan, the faculty was able to view the student's ID picture upon hovering on the assigned seat. In generating a seat plan, the class setting was automatically determined by the system based on the room name whether it was a classroom or a
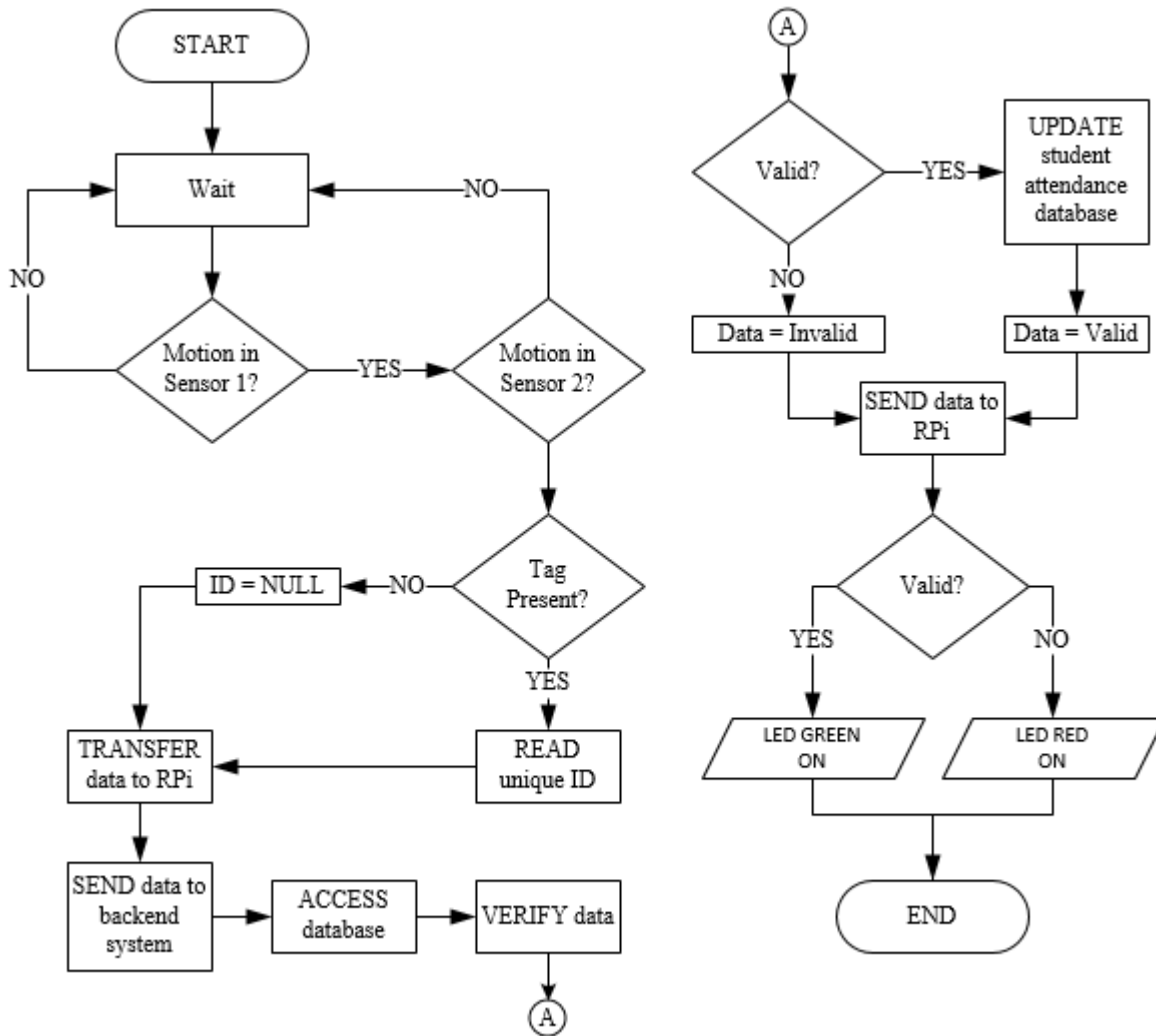
Figure 3: System flowchart of the Attendance Monitoring System

laboratory. The row and column was only editable in a classroom setting. The seating order had a variety of choices: alphabetical (row: left to right and column: left to right), reverse alphabetical, and random. The faculty were also able to manually assign students by selecting a student from the class list and the desired seat from the ready-made classroom layout. The page catered scenarios like a student requests for a change of assigned seat, thus the seat plan could be editable. A seat plan was required at the start of using the system.

Attendance Page When a class was selected, the faculty was redirected to another page where the class list with the detailed attendance record of the students was displayed. The student's total number of unexcused absences were highlighted red when 12% of the prescribed number of class or laboratory hours were reached, yellow when more than 20% of the prescribed number of class or laboratory hours were reached [3], and gray when 3 consecutive absences were reached. The attendance of the students were able to edit manually whether they were present, late, or absent (excused or unexcused) on a particular day. The faculty was able to add excuse letters in image format and remarks. Faculty were able to edit the time in, time out, and the allowable time to be late; and could view the detailed log by hovering the
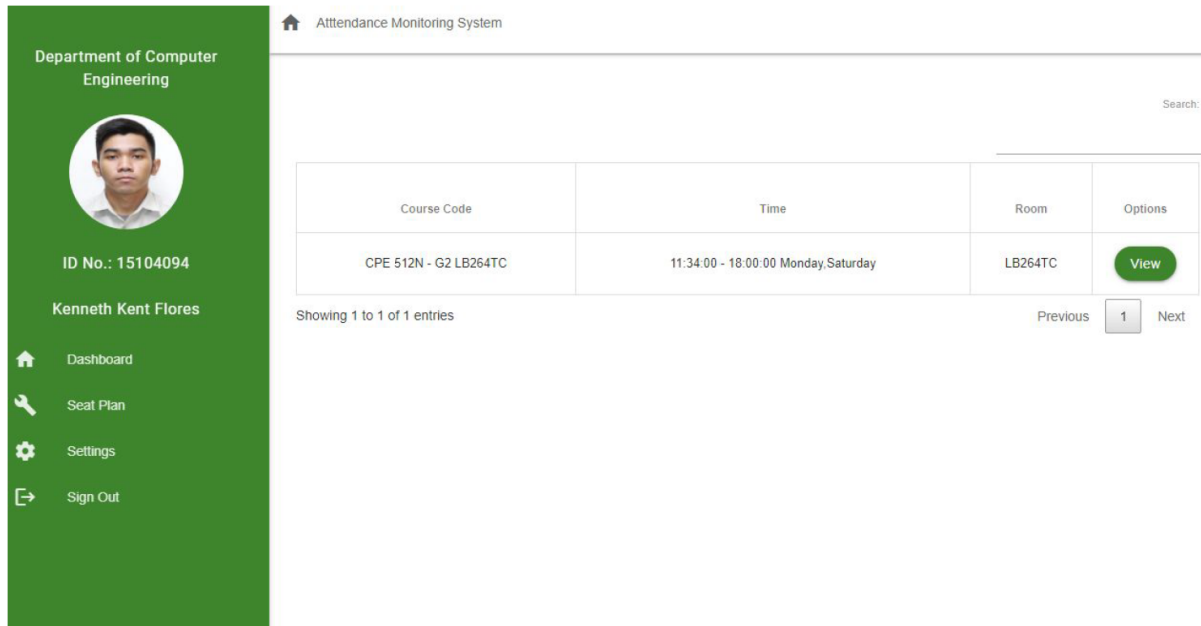
Figure 4: UI Design of Faculty's Dashboard

attendance status. In addition, the data obtained from the RFID reader regarding unregistered students and an unknown person could be viewed by hovering a specific date.

3.2.3   Student Dashboard

The student's dashboard in Figure 5 showed the attendance record of the student. The total number of absences was displayed to remind students of their attendance status in class; a yellow highlight for dropped students, a red highlight as a candidate for dropped, and a gray highlight for readmission.

3.2.4   Chairperson Dashboard

The dashboard in Figure 6 showed the detailed attendance record to correspond to the selected class. The chairperson could monitor the attendance of classes under their jurisdiction.

3.2.5   Setting Page

All users were able to change their password on the settings page with a minimum of 8 characters and a maximum of 15 characters. The user was also required to re-type the password for verification. For security measurement, the password was encrypted in the database with the use of a hashing technique.

In summary of the aforementioned actions of all the users in the web application, a top-level use case is shown in Figure 7.

3.3   Testing

3.3.1   Unit Testing

The responsiveness of the UHF RFID was tested with its respective RF Power of 26 dB, time interval and different time trials. The expected number of tag count were computed before tests started using

8
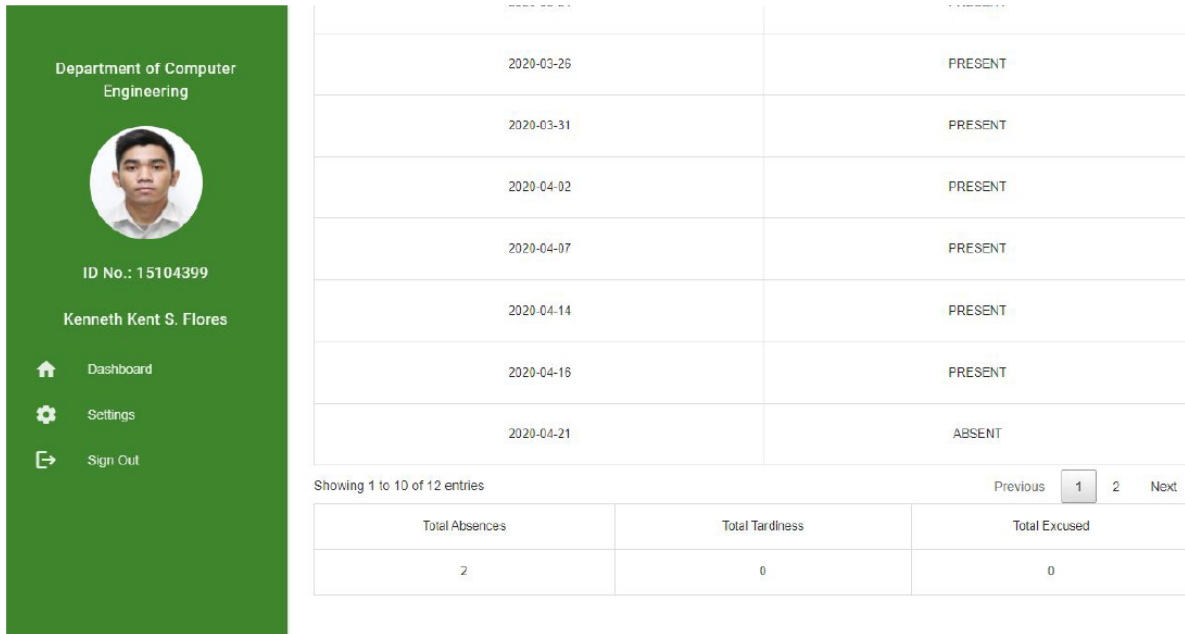
Figure 5: Student's Attendance Monitoring Web Application

Figure 6: Chairperson's Attendance Monitoring Web Application

equation 1

$$x = \frac{tot}{i} \tag{1}$$

where tot was the total time or the time trials, and i was the time interval that was set to 10 ms; the lowest time interval of the RFID module. The value for tot ranged from 10 to 60 seconds (sec). The set range was selected to have comparative data from different time trials, and was only limited to 60 sec as i had

Figure 7: Illustration of the use cases the faculty, students, and chairperson performed in the system
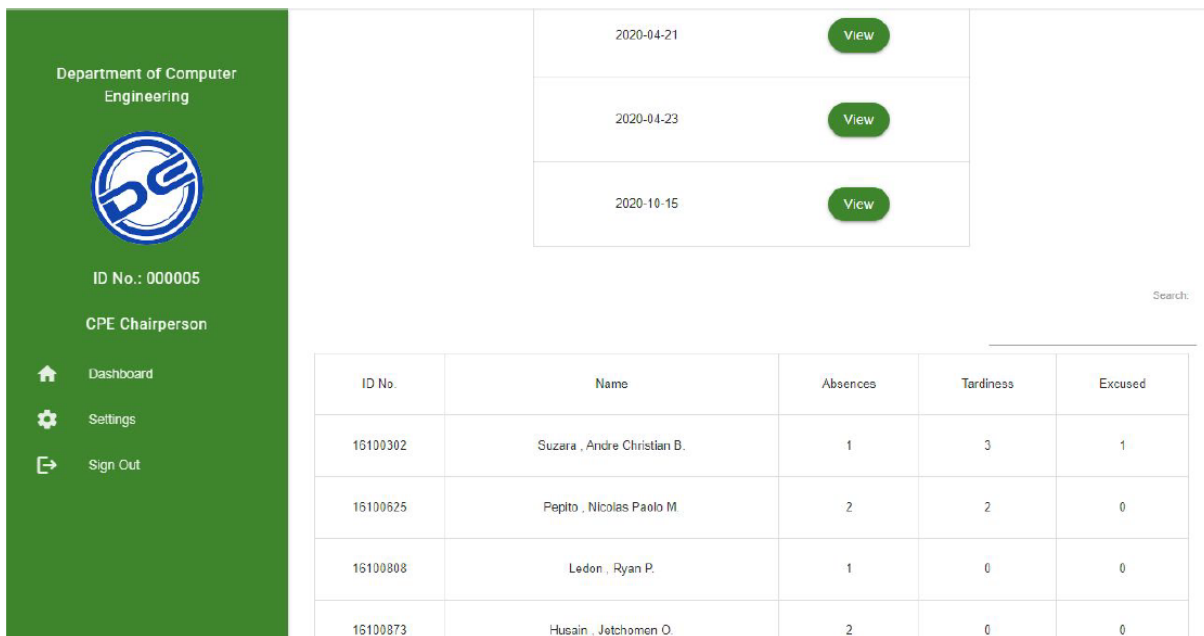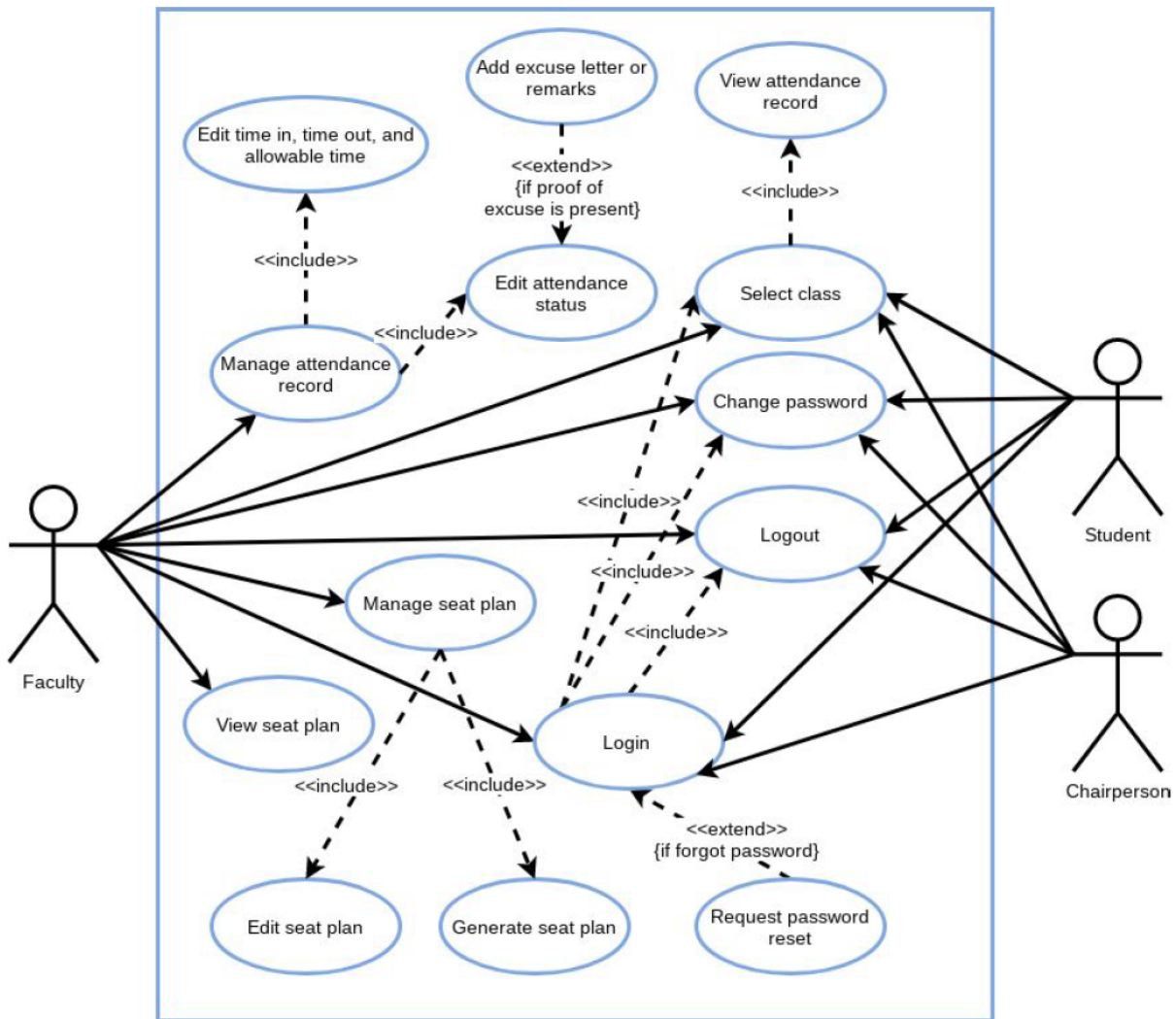
the same value despite increasing the tot.

The RFID tags, together with the UHF RFID reader and antenna, were tested to make sure that it could read the frequency emitted by the tags in different reading orientations. There were two RFID orientations that were considered in the testing that showed the parallel and perpendicular orientation. Parallel orientation, shown in Figure 8.a, is when the RFID tag is positioned or is facing vertically with respect to the RFID reader. In contrast, the perpendicular orientation, shown in Figure 8.b, is when the RFID tag is positioned horizontally with respect to the RFID reader.

Different reading ranges of the RFID reader were tested to check whether the range of the RFID antenna functioned as a "walk-in" system. The RFID reader could read more tags in a perpendicular orientation than in a parallel orientation with an average response time between 70 ms and 200 ms depending on its range, however, during the range test, both orientations achieved a 100% success rate from the 50 trials conducted. Even though the response time of the RFID reader is less than a second and it could detect within the 3 m range, its reading capabilities towards the RFID tags' orientations could affect the performance of the system since the RFID antenna had a linear reading polarization. An RFID antenna with circular reading polarization could be used to be able to read the RFID tags in any
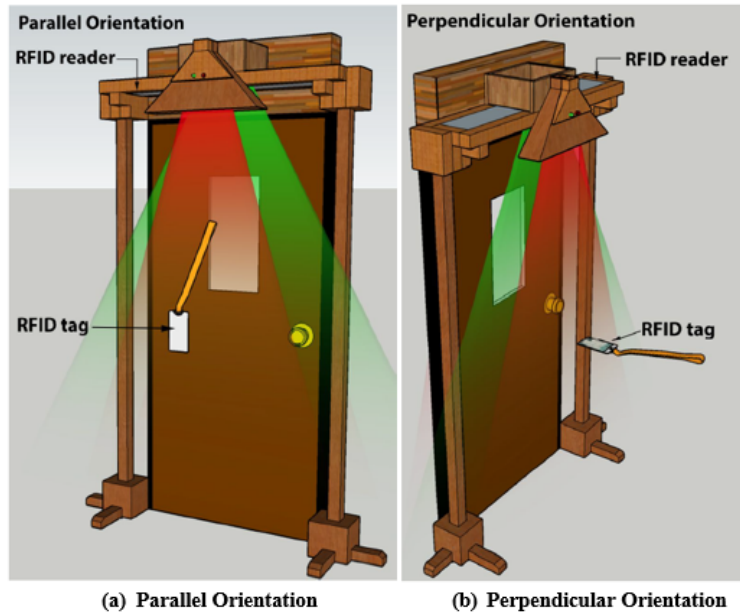
Figure 8: RFID tag detection in different orientation

orientation. The hardware was not acquired by the researchers due to unforeseen problems.

The PIR motion sensor was tested to validate if a motion was detected and to acquire the actual total response time. According to the HC-SR501 datasheet [1], the motion sensor's datasheet, the delay time could be adjusted between 0.3 sec and 5 minutes (min). The delay time is the time where the motion sensors remain at its "on" state after the motion was detected, the blocking time is the time where the motion sensors could not detect any motion, and the total response time is the summation of the blocking time and delay time; it also determines the time interval where the sensor could detect the next motion after reading the previous one. The motion sensors were configured to its minimum delay time to support the walk-in feature of the system. Each sensor was also set to its single motion trigger setting where it enabled its delay time once motion was detected and waited for the blocking time to expire before detecting another motion. After conducting 50 trials, the average response time of the 1st and 2nd motion sensors were 5.58 sec and 10.2 sec, respectively.

The motion sensors were also tested at different proximity to check the required reading range. According to the HC-SR501 datasheet [1], the detecting range was up to 7 m. Since the distance from the floor to the top of the door frame was within 3 m, the testing range was set into it. The motion sensors were set to their maximum reading sensitivity during the test. The test was done by having a 10 sec interval after a motion was detected before moving across the motion sensor's path again. Their range was able to meet the required distance for the system, however there were times that the sensor cannot detect motion when tested. As the acquire motion sensors had a longer response time, an alternative for this is a motion sensor with a faster response time and possibly, without a delay and blocking time. The hardware was not acquired as the researchers faced some unforeseen problems upon acquiring the alternative hardware.

The Raspberry Pi 3 was tested into three parts. First, the Raspberry Pi 3 was connected to the RFID reader and motion sensor to verify data were acquired correctly. Second, the acquired data was used to transmit it to the backend system for data validation. The data validation from the backend was sent back to the Raspberry Pi 3. The validated data was then displayed with the use of the two LEDs. The Raspberry Pi 3 was also tested with the different scenarios in class, selected from Appendix G, on how

it responds and how it treats the data received. All tests done with the Raspberry Pi achieved a 100% success rate in receiving and sending data to and from other modules, and met the expected output for all of the scenarios. The tests of the scenarios were not integrated with the web application and database. The Raspberry Pi was suitable for its function of the system, however, it cannot determine what happens in the actual scenario such as how many students were involved or did the student truly enter or exit the classroom. Implying that the system had flaws in these types of situations, and because of the limited capabilities of the other components that were used.

The web application was tested to verify that it can monitor and display the essential information with regards to the attendance of the student. This indicated that the web application was able to perform the main features of the system which was the user authentication, seat plan, and attendance record. In addition, it should display and perform the expected output of each of the test cases. The database was tested to validate if it could create, retrieve, or update the information in the web application. Each of the features in the web application achieved a 100% success rate from the 40 trials that were conducted. Hence, the web application was able to perform user authentication; edit, view, and generate seat plans, and view and edit the attendance records. In addition, the web application was able to display the essential information that consists of the list of classes, a class list with its attendance record, a summarized daily attendance report, and a layout of the seat plan.

3.3.2   Integration Testing

The UHF RFID reader, two PIR motion sensors, and two LEDs were integrated into the Raspberry Pi 3 as one hardware module. A person with a RFID tag tested the reader and motion sensors' specific functionality to ensure that the Raspberry Pi 3 received and processed the information. Likewise, the researchers tested the backend system if it could set up and start the web server for the users to gain access to the web application.

3.3.3   System Testing

A test was done to verify if the inputs from the hardware system displayed two outputs from the backend system; the green or red LED lit up for student's validation via Raspberry Pi, and the attendance status of the student reflected on the users' web application. In addition, a test was also done to the database to ensure its functionality. All of the possible issues when executing the overall flow of the system were considered such as problems in interfacing the hardware and web application, system downtime, system delay, errors in loading the webpage, collection of unwanted data, and potential software bugs.

3.3.4   User Acceptance Testing

The researchers used stratified sampling and the strata were lecture rooms and laboratories managed by the Department of Computer Engineering and Mechanical Engineering. The chosen lecture room catered at most 2 classes while the laboratory room catered at most 3 classes. Only 1 out of the total rooms was sampled considering only one hardware setup was available for one room, full load schedules, and the testing duration of one month. Equation 2 and 3 [2] were utilized to compute the student sample size, where Z is the standard score (1.96 or 95% confidence level), p is percentage (50%), c is the confidence interval (0.05), and *pop* is population (49 students).

$$sample\ size = \frac{Z^2\ x\ p\ x\ (1-p)}{c^2} \tag{2}$$

$$Scaled\ sample\ size = \frac{ss\ x\ pop}{pop + ss - 1} \tag{3}$$

Accordingly, the scaled sampling size for the students were 146 and 23 considering a sampling population of 234 students for the 8 classes in the lecture room and 24 students for 3 classes in the laboratory, respectively. Faculty members part of the 11 classes and one chairperson were also included. The system was supposed to be tested to ensure the functionality was correct according to the given requirements specifications, however, due to the pandemic the researchers did a simulation test according to the aforementioned test cases. The test also ensured that the outputs displayed by the system were correct based on the inputs of the hardware system and the users.

The web application can be accessed through different devices: desktop, laptop, tablet, and smartphone. Devices should be supported by the following operating system: Windows, Android, iOS, and macOS. For better display, the following browsers were required: Chrome, Safari, Mozilla, and Opera.

3.3.5   Data Management

The data from the hardware system and the user's information, which was gathered personally from the participants, was stored in a MySQL database which runs on a personal laptop that was password-protected and could only be accessed by the researchers. The users' name had a code equivalent to the RFID tags assigned to them. The database was backed up to have protection against a primary loss of data or corruption. Both soft and hard copies of the data were available for a minimum period of three (3) years. The soft copies were permanently deleted using a third party wiping program while the hard copies were shredded.

4   Presentation, Analysis, and Interpretation of Data

The researchers conducted a unit test of the following modules: UHF RFID, motion sensors, hardware controller, and the web application. The purpose of the test was to know how fast and responsive the UHF RFID was in reading the RFID tags with certain parameters such as the range and orientation. The test results of the UHF RFIDs responsiveness shown in Table 1 indicated that the orientation of the RFID tags with respect to the RFID reader affected the total number of tags that were counted. This implied that the perpendicular orientation effectively contributed to a higher number of tags that were counted than the parallel orientation. In addition, the results showed that there was a decrease of the total number of tags that were counted when the reading range of the RFID was increased.

The actual results showed a significant amount of difference compared to the expected results which was the ideal number of tags that should be counted by the UHF RFID. Range, orientation, and RF Power contributed to the big difference between the actual and the expected results thus affected the actual count of RFID tags or the responsiveness of the UHF RFID.

The UHF RFID was tested for its range and the summarized results are shown in Table 2. The purpose of the test was to know the reading range capability of the UHF RFID with certain parameters such as the range and orientation. A total of 50 tests were conducted for each range with a different orientation. The results indicated that the UHF RFID achieved a 100% success rate for all ranges and orientation. The results showed that UHF RFID reader was capable of reading the RFID tags with the different ranges and orientation. In addition, different orientations did not affect the reading range of the UHF RFID.

Table 1: UHF RFID Responsiveness Test Results

RF power				26 db			
Interval Time				10 ms			
Expected Result (count)							
Range	Orientation	10 sec	20 sec	30 sec	40 sec	50 sec	60 sec
		1000	2000	3000	4000	5000	6000
Actual Result (count)							
0-1 m	Parallel	43	129	226	312	425	513
	Perpendicular	125	275	468	568	644	781
1-2 m	Parallel	44	116	160	222	289	394
	Perpendicular	92	221	367	498	552	647
2-3 m	Parallel	44	115	140	211	275	330
	Perpendicular	52	118	163	220	290	381

Table 2: UHF RFID Responsiveness Test Results

Range	Orientation	Success(%)
0-1 m	Perpendicular	100
	Parallel	100
1-2 m	Perpendicular	100
	Parallel	100
2-3 m	Perpendicular	100
	Parallel	100

The motion sensors were tested for its responsiveness to detect motion. A total of 50 tests were conducted. The linear graphs shown in Figure 9.a and Figure 9.b were the motion sensors' delay time, blocking time, and total response time. The minimum delay time of the first and second motion sensors were approximately 1.6 sec. and 3 sec., respectively. The response time of the first motion sensor was between 4 to approximately 8 sec. with an average response time of 5.58 sec., while the second motion sensor was between 8 to approximately 13 sec. with an average response time of 10.2 sec. The test results of the motion sensors' ranges shown in Table 3 and Table 4 indicated how effective the motion sensors could detect motion within 0 to 3 m. The testing phase was done 30 times.

For the first motion sensor, it achieved a 96.55% success rate at 0-1 m. This was because the reading area of the motion sensor was conical in nature thus having the closest range also had the smallest reading area coverage, however, it achieved 100% success rate within the 1-3 m range since the farther the range, the bigger the reading area coverage. The average time response of the first motion sensor affected the sensor's performance.

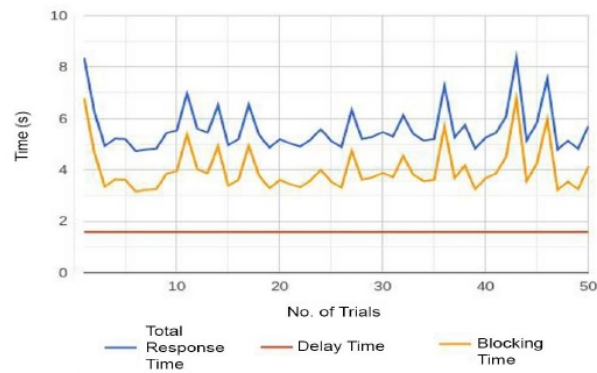Table 3: Motion Sensor 1 Range Test Results

Range	First Motion Sensor			
	Number of Success	Number of Fail	Success (%)	Fail (%)
0-1 m	29	1	96.55	3.45
1-2 m	30	0	100	0
2-3 m	30	0	100	0

For the second motion sensor, it did not achieve 100% success rate from all range sets because of its average response time of 10.2 sec. This indicated that even though the motion was within its detecting range, the set 10 sec interval was not enough for it to detect the next motion.

Table 4: Motion Sensor 2 Range Test Results

Range	First Motion Sensor			
	Number of Success	Number of Fail	Success (%)	Fail (%)
0-1 m	29	1	96.55	3.45
1-2 m	26	4	84.61	15.39
2-3 m	23	7	69.56	30.44

(a) Motion Sensor 1
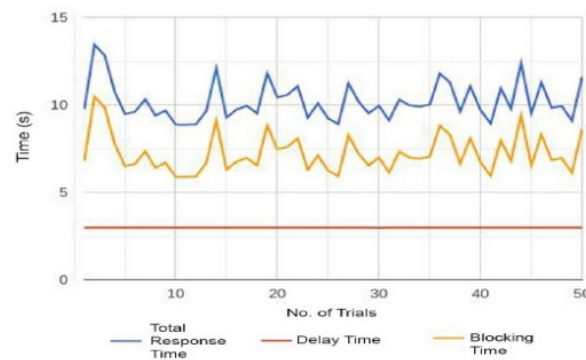
(b) Motion Sensor 2

Figure 9: Responsiveness Test Results in Linear Graph

Table 5: Hardware Controller Test Results

	No. of Trials														
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Motion Sensor 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Motion Sensor 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RFID Reader	REG	UN REG	UN REG	REG	REG	REG	UN REG	REG	UN REG	REG	NO TAG	NO TAG	NO TAG	NO TAG	NO TAG
Backend	VALID	IN VALID	IN VALID	VALID	VALID	VALID	IN VALID	VALID	IN VALID	VALID	IN VALID	IN VALID	IN VALID	IN VALID	IN VALID
Green LED	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
Red LED	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON	ON	ON

A summarized test result shown in Table 5 was about the connection of Raspberry Pi 3 with other modules such as the motion sensors, RFID reader, backend system, and the LEDs. There were three basic scenarios executed as data were gathered. First, both of the motion sensors and the RFID reader detected motion and a registered tag (REG) respectively; thus results showed valid data. Second, a motion was detected but the tag was unregistered (UNREG), and resulted in invalid data. Lastly, motion was detected but no tag was detected (NO TAG), thus, also resulted as invalid.

On the results under the motion sensors, the check mark represents that motion was detected. For the RFID reader, the result was marked either REG, UNREG, or NO TAG. Both of the inputs were sent to the back end system to determine if they were valid or not. The validated data was sent back to the Raspberry Pi to display output using the LEDs. The green LED lit up as data was valid, while the red LED lit up as data was invalid. All of the tests conducted displayed correct results, and proved that the Raspberry Pi 3 was capable of receiving and sending data to and from other modules.

Table 6 summarizes the results when testing the expected action of the system under different scenarios. Each scenario is performed 10 times in a controlled environment. The purpose of the test was to know how the system would respond to the given scenarios. The appropriate action of the system is critical as it could affect the student's attendance. As observed in all 10 trials, the system responded correctly in different scenarios. Furthermore, Table 7 presents the success rate of the web application and database's functionality which were evaluated 40 times with different test cases. The following main features focused on this study was the logged credentials, seat plan, and the attendance record. Each of the said features achieved 100% success rate, in which it indicate that the web application can fully log in and out users; edit, view, and generate seat plans; and edit and view attendance records. The data results also showed that the web application was capable of displaying important information such as a list of classes, a summarized daily attendance report, a class list with the attendance record, and a seat plan layout. Additionally, Table 8 shows efficiency of the developed system in a simulated classroom setting. Likewise, the systems act according to the intended behavior in all ten trials.

5 Conclusion

The hardware modules were able detect in certain ranges and orientations. The UHF RFID module achieved a 3 m reading range thus it has the capability as a walk-in RFID. As for the two motion sensors, both achieved a reading range of 3 m and were able to detect motion at 16 sec. total response time. In addition, the hardware controller was able to process the data sent and received to and from other modules. The selected list of contingencies' results showed that the hardware modules were able to detect a tag, detect and identify a person's direction, validate the data, and display the validated data. For the developed web application, the three user types were able to access it using their credentials. They were able to view the updated attendance. The faculty user could view and edit the attendance; and view, edit, and generate a seat plan. The web application also displayed correct details of the class, list of classes, attendance, and seat plan. In addition, the web application was also capable of addressing certain contingencies.

6 Recommendation

Despite the number of tests the researchers had for the motion sensor, its blocking time and delay time is not accurate to its datasheet, thus its total response time is high and not suitable for the ideal system performance. The unforeseen specification problems were due to the researchers' credence to the acquired hardware components since its datasheet is ideal in the system performance, thus, it is recommended

Table 6: Prototype efficiency test under different scenarios

Scenarios		Expected Response	Efficiency
1. Throwing of ID inside or outside the room		RFID reader will detect a tag but will discard it.	10/10
2. Students scanned by both motion sensors and RFID reader without fully going in or out		2. Students scanned by both motion sensors and RFID reader without fully going in or out	10/10
3. First person passed by the first motion sensor then scans RFID tag, and a second person passed by the 2nd motion sensor		First person will be detected, and the second person's data will be discarded.	10/10
4. One person staying on the motion sensor, the other person staying on the 2nd motion sensor, then a person enters or exits		An unknown person will be detected, and the third person's data will be discarded.	10/10
5. A student with an RFID tag attempts to enter or exit the room, triggers one of the motion sensors and RFID reader but goes back to the direction where he/she came from.		Data detected will be discarded.	10/10
6. Two students with simultaneous entry or exit (opposite direction)	Both with RFID tags	An unknown person will be detected.	10/10
	Both without RFID tags		10/10
	One with RFID tag and the other without RFID tag		10/10
7. Two students with simultaneous entry or exit (same direction)	Both with RFID tags	A single motion and only one tag will be detected.	10/10
	Both without RFID tags	An unknown person will be detected	10/10
	One with RFID tag and the other without RFID tag	A single motion and the tag will be detected.	10/10
8. Passerby near the range of the sensor	Passerby on one side	Data will be discarded.	10/10
	Passerby on both side	An unknown person will be detected.	10/10
9. First person staying within the RFID antenna then a second person enters or exits		First person will be detected, and the second person will be discarded.	10/10

to ascertain the specification before and after acquiring. It is also recommended to use a different motion sensor with lesser delay time with no blocking time, which will increase the responsiveness of the overall system. In addition, a motion sensor that can detect multiple motions simultaneously, it can be another type of motion sensor as PIR motion sensors depend on body heat. Lastly, it is recommended to use a UHF RFID Reader with a conical reading coverage or circular polarization, as it has better reading capability than the linear polarization. This will increase the count accuracy of reading multiple tags in different ranges and orientation with respect to the reader's RF power and interval time. Future researchers can use this study to implement projects involving attendance, not only in schools or universities but also in companies or organizations.

Table 7: Web Application efficiency test under different test cases

Test Cases	Database Action	Expected Response	Success Rate (%)		
			Faculty	Student	Chairperson
Login	Retrieve	Redirect to the user's dashboard. Display the list of classes with its class code, schedule, and room number.	100	100	100
Forgot password			100	100	100
Change password	Update	New password update	100	100	100
View list of classes	Retrieve	Display class list with the attendance record and the summarized daily attendance	100	100	100
Edit attendance status	Update, Retrieve	Display the update attendance record	100	100	100
Edit attendance allowance	Update, Retrieve	Display the updated allowance in a class	100	---	---
View seat plan	Retrieve	Display existing seat plan layout	100	---	---
Generate seat plan: Automatic	Create, Retrieve	Display generated seat plan layout	100	---	---
Generate seat plan: Manual			100	---	---
Edit seat plan	Update, Retrieve	Display edited seat plan layout	100	---	---
Insert excuse letter	Update, Retrieve	Display excuse letters as image format	100	---	---
Add remarks	Update, Retrieve	Display the save remarks	100	---	---

Table 8: Web Application efficiency test in simulated classroom setting

Scenarios		Expected Response	Efficiency
1. Time in Before the 15 min. allowance time start		Students will be recorded as unregistered.	10/10
2. Multiple Logging Time		Student log time will append and the first log in time will be the student's attendance status.	10/10
3. Unknown Person		A number of unknown people going in or out will be displayed.	10/10
4. Unregistered Student		Students will be recorded and will be displayed as unregistered.	10/10
5. Time Out Beyond Class End Time	Automatically	Students will be automatically timed out displaying the class end time.	10/10
	Manually	Students will be recorded as unregistered.	10/10

References

[1] Motion detector, hc-sr501. [Online; accessed 1-December-2020].

[2] Sample size formulas for our sample size calculator. [Online; accessed 1-December-2020].

[3] *Student Manual 2018 Edition*. University of San Carlos, Cebu City, Cebu, Philippines, 2018.

[4] M. A. Abas, Auji, and M. Dahlui. Attendance management system (ams): Comparison of two different approaches. In *2017 International Conference on Engineering Technology and Technopreneurship (ICE2T)*, pages 1–7, 2017.

[5] L. Ada. Pir sensor overview. [Online; accessed 1-December-2020].

[6] A. Amigud, J. Arnedo-Moreno, T. Daradoumis, and A.-E. Guerrero-Roldan. An integrative review of security and integrity strategies in an academic environment: Current understanding and emerging perspectives.

computers & security, 76:50–70, July 2018.

[7] J. D. Aniñon, K. K. Flores, C. S. K. Otadoy, J. P. Rodas, and J. F. Tabaco. A study on faculty adn student's perspective on attendance monitoring in university of san carlos. *unpublished*.

[8] J. D. Aniñon, K. K. Flores, C. S. K. Otadoy, J. P. Rodas, J. F. Tabaco, and C. nera. Comparative study on different technologies used for attendance monitoring. *unpublished*.

[9] R. Component. Single board computers overview. [Online; accessed 1-December-2020].

[10] K. Demir and Y. A. KARABEYOGLU. Factors associated with absenteeism in high schools. *Eurasian Journal of Educational Research*, 16(62), February 2015.

[11] B. A. Jacob and K. Lovett. Chronic absenteeism: An old problem in search of new answers. *Brookings Institution, Washington, DC*, 2017.

[12] A. Kalla and D. K. Tiwari. Review on student attendance maintenance system: A discontentment. In *Proceedings of the International Conference on Recent Cognizance in Wireless Communication & Image Processing*, pages 987–997. Springer, 2016.

[13] N. Khalid and K. Mehmood. Effects of absenteeism on students performance. *International Journal of Scientific and Research Publications*, 7(9):151–168, December 2017.

[14] E. Lamprecht. The difference between ux and ui design - a beginner's guide. [Online; accessed 1-December-2020].

[15] M. Olagunju, A. Adeniyi, and T. Oladele. Staff attendance monitoring system using fingerprint biometrics. *International Journal of Computer Applications*, 179(21):8–15, September 2018.

[16] M. N. Osman, K. A. Sedek, M. Maghribi, and N. H. M. Faisal. Anotify: A fingerprint biometric-based and attendance web-based management system with sms notification for industrial sector. *Journal of Computing Research and Innovation*, 3(1):36–45, October 2018.

[17] M. Raut, S. Kokate, S. Shinde, S. Karpe, and S. Barahate. Virtual biometric fingerprint attendance system. *IJSRD*, 3(1):511–513, 2015.

[18] S. Smiley. 3 guidelines for choosing a passive uhf rfid antenna. [Online; accessed 1-December-2020].

[19] R. O. Solis, J. Sarmiento, and J. Fortes. Use and operation of radio frequency identification (rfid) within the 13.553-13.67 mhz, 918-920 mhz, and 2446-2454 mhz bands. [Online; accessed 1-December-2020].

[20] S. Stobart and D. Parsons. *Dynamic Web Application Development Using PHP and MySQL*. Cengage Learning, London, 2008.

[21] A. Wang, A. Chang, A. Mark, and K. Louie. Material design. [Online; accessed 1-December-2020].

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